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(71) Applicant: International Business Machines Corporation
Old Orchard Road
Armonk, N.Y. 10504 (US)

(72) Inventor: Barker, Barbara A.
2800 Carmel Drive
Round Rock TX. 78681 (US)

Edel, Thomas R.
9410 Topridge Drive
Austin - TX. 78750 (US)

Stark, Jeffrey A.
2905 Valleyview Drive
Grapevine - TX. 76051 (US)

(74) Representative: Tubiana, Max
Compagnie IBM France Département de Propriété Intellectuelle
F-06610 La Gaude (FR)

(54) **Method of dynamic actuation of background windows for priority applications.**

(57) A method is disclosed for dynamically actuating a selected background window displayed on a computer system among a plurality of windows which at least partially overlap the background window. The output of data from the selected background window is monitored and is utilized to selectively provide an unencumbered display by altering the display sequence of the windows to automatically promote the background window to the uppermost display position, in accordance with the state of a display attribute associated with the background window. After the output of data by the selected window has occurred, the display attribute may be utilized to determine whether or not the selected window returns to its previous display position or remains in the uppermost display position.

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Description

METHOD OF DYNAMIC ACTUATION OF BACKGROUND WINDOWS FOR PRIORITY APPLICATIONS

BACKGROUND OF THE INVENTION

This invention relates in general to methods for the efficient utilization of multiple computer applications in a multi-tasking system and in particular to methods which permit the output of one application to selectively alter the sequence of the display of a plurality of overlapping windows displaying the multiple computer applications. Still more particularly, the present invention relates to a method whereby a user may elect to assign a priority to the output of a selected application, such that the window in which the application is displayed will automatically be promoted an uppermost display position in response to the outputting of data from that application.

It is possible with modern computer systems for a computer to simultaneously execute several software applications. The execution of multiple applications simultaneously is often referred to as "multitasking." It is also possible for multiple interactive work stations to be linked to a host computer whereby a user may simultaneously execute several software applications by utilizing a work station and the host computer. It is desirable in such environments to allow the user to view some or all of the applications simultaneously. This is often accomplished by the utilization of the concept of "windows" wherein all or part of multiple applications are displayed in separate viewports or "windows" of a computer system video display system. The complexity of many software applications require substantially all of a computer's video display and it is therefore common to overlay one window upon another window, or to represent a second application with a miniature graphic representation or "icon." Further, it is known to have multiple software applications present on a computer display simultaneously, one or more of which may be active at any given time, and which may be displayed in a window or icon.

As an example of the above, a user may desire to have three separate applications invoked each time the user starts up his or her computer system. A word processor program and a spread sheet may be initially displayed in windows on the display system while an electronic mail application is initially displayed as an icon at the bottom of the display. When the user desires to send or receive electronic mail to or from other computers connected to his or her computer via a computer network, the user must expand the icon into a window, send or receive the mail, and then shrink or "tokenize" the application into an icon once again.

A problem inherent in such multi-tasking systems is the inability of an interactive application to display a change in status while it is overlayed by another application or displayed in an icon status. Thus, if the above described user desires to spend most of his or her time working within a word processing or spread sheet environment, it will not be possible to determine whether or not incoming electronic mail has arrived or what type of mail is awaiting response. Certain known software applications which are utilized in a multi-tasking environment utilize a bell or tone to indicate a change in status of one application to the user. However, many software applications have multiple states of interest to the user which may not be indicated by an audio tone. For example, an application may require an input from a user, the applica tion may indicate that execution is taking place or has concluded, or the application may indicate an error state.

One known solution for this problem has recently been proposed which utilizes a miniature graphic representation or "icon" which is indicative of an individual computer task. This icon is defined or characterized by a set of graphic parameters which may include color, textual content and duration. A change in the status of a first computer task is then indicated by a variation in one or more of the graphic parameters. For example, the color or graphic content of the icon may be altered, or the icon may be turned off or "blinked" to indicate a specific change in status.

While this proposal represents an advance in the art, it is only useful for indicating a change of status of an application which has been tokenized or turned into an icon and, after the changed state has been indicated, it is still necessary for the user to deactivate the application in which he or she is currently working and activate the tokenized computer application. Additionally, this proposed system may not be utilized in a situation wherein the computer application program is displayed within a window which is overlapped by a second active application.

Of course, those skilled in the art will appreciate that known systems exist whereby messages from the system operator may take precedence over an active application and be displayed for the utilization of a user. However, no method exists whereby the outputting of data from one application may be automatically utilized to alter the display sequence of a plurality of overlapped windows whereby a user may be automatically and dynamically made aware of the output of data by an overlapped application by the promotion of that application to the uppermost display position.

Therefore, it should be obvious that a need exits for a method whereby the output of data from an application displayed in an overlapped window may be utilized to automatically promote that window to an uppermost display system so that a user may be aware of the output data without the necessity of activating the second application.

SUMMARY OF THE INVENTION

It is therefore one object of the present invention to provide an improved method for the efficient utilization of multiple computer applications.

It is another object of the present invention to provide an improved method for the efficient utilization of multiple computer applications in a multi-tasking system wherein the applications are displayed in a plurality of overlapping windows.

It is yet another object of the present invention to provide an improved method for the efficient utilization of multiple computer applications in a multi-tasking system wherein the output of data from a selected application may dynamically actuate a background window.

The foregoing objects are achieved as is now described. The method of the present invention may be utilized to dynamically actuate a selected background window which is displayed on a computer system among a plurality of windows which at least partially overlap the background window. The output of data from the selected background window is monitored and is utilized to selectively provide an unencumbered display by altering the display sequence of the windows to automatically promote the background window to the uppermost display position, in accordance with the state of a display attribute associated with the background window. After the output of data by the selected window has occurred, the display attribute is utilized to determine whether or not the selected window returns to its previous display position or remains in the uppermost display position.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a pictorial representation of a plurality of windows displayed on a computer display screen;

FIGURE 2 is a pictorial representation of the plurality of windows of Figure 1 after selective alteration of the display sequence has occurred in accordance with the method of the present invention; and

FIGURE 3 is a logic flow chart of the method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures and in particular with reference to Figure 1, there is depicted a pictorial representation of a computer display screen 10 upon which are displayed a plurality of overlapping windows 12, 14, and 16. As those skilled in the art will appreciate, windows 12, 14, and 16 are typically overlapped in a sequence which is dependent upon the order in which the windows were called or opened. That is, window 16 was opened and thereafter the opening of window 14 caused window 14 to overlap window 16. Next, window 12 was opened, overlapping window 14. Of course, each window may display a different computer application program. That is, window 16 may display a spread sheet program, window 14 may display a word processing program and window 12 may display a graphics application.

In accordance with the method of the present invention, each window displayed within computer display screen 10 includes a display attribute associated therewith which may be utilized to control the selective alteration of the display sequence in accordance with the output of data from a designated application. For example, a user may make a request for data from a database application and return to a word processing application wherein it is desired to incorporate that data. When the data requested has been obtained, if the display attribute associated with that window permits, the database application will selectively alter the sequence of displayed windows to permit the database application to be displayed in the uppermost display position.

Referring now to Figure 2, a pictorial representation of the plurality of windows displayed within computer display screen 10 is illustrated, after a selective alteration of the display sequence has occurred in accordance with the method of the present invention. As can be seen, the generation of output data, "The solution is XYZ" has caused a selective alteration in the displayed sequence of windows 12, 14, and 16. As is illustrated, window 14 has been "promoted" to the uppermost display position, overlapping windows 12 and 16. This action has occurred dynamically, in accordance with the state of a display attribute associated with window 14 and the occurrence of the output of data from the application displayed therein. The display attribute associated with window 14 in the depicted embodiment permits the alteration of the display status of window 14 as a result of the output of data from the application, as depicted in Figure 2.

With reference now to Figure 3, there is depicted a logic flow diagram illustrating the method of the present invention. As may be seen, the process begins at block 20 with both background and foreground applications executing programs in a multi-tasking system wherein the applications are displayed in a plurality of windows which at least partially overlap in a selected sequence. Block 22 illustrates the occurrence of the generation of output data in a selected one of the applications currently executing. Thereafter, block 24 depicts the determination of whether or not the application generating the output data is the current "top" window, or the window in the uppermost display position. If so, the output data is displayed in the appropriate window, as illustrated in block 32.

In the event the application generating the output data is not the uppermost window, block 26 illustrates the determination of whether or not the

display attribute associated with that window permits the interrupt promotion of that window to the uppermost display position. If not, block 28 depicts the output data remaining obscured and the program returns to the execution states illustrated in block 20. Where the display attribute associated with the window attempting to output data permits the interrupt promotion of that window to an uppermost display position, block 30 depicts the position of an unencumbered display by the selective alteration or rearrangement of the overlapped windows to promote the "output" window to the uppermost display position and the suspension of the activity of the previous "top" window application. Next, the output data is displayed, as depicted in block 32.

After the display of output data has occurred, block 34 illustrates a determination of whether or not the display attribute associated with the output window indicates that the window in question must revert to its previous overlapped state. If not, block 36 indicates that the altered display sequence will remain intact and the program will return to block 20 and continue execution. If revision of the display sequence is indicated by the display attribute, block 38 depicts the demotion of the uppermost displayed window to its prior overlapped state. Thereafter, the program returns to the execution status illustrated by block 20.

In accordance with the method of the present invention, a novel display attribute associated with selected windows in a multi-tasking system is utilized to permit the dynamic promotion of an overlapped window to an uppermost display position in response to the output of data by the application displayed within that window. Further, the alteration of the display sequence may be retained or reverted in accordance with a second aspect of the novel display attribute of the present invention. In this manner, a user may selectively operate in one application while waiting for output data from a second application without the necessity of periodically entering the second application to determine the status thereof.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

Claims

1. A method of dynamically actuating a selected one of a plurality of computer application programs which are simultaneously active and displayed on a computer system in a plurality of windows which at least partially overlap, said method comprising the steps of:
monitoring the output of data from said selected one of said plurality of computer application programs; and
providing an unencumbered display of a window displaying said selected one of said plurality of computer application programs in response to the output of data from said selected one of said plurality of computer application programs.

2. The method according to Claim 1 wherein said step of providing an unencumbered display of a window displaying said selected one of said plurality of computer application programs is accomplished by selectively altering the sequence in which said plurality of windows overlap.

3. The method according to Claim 1 further including the step of:
establishing a display attribute for each of said plurality of windows and wherein said step of providing an unencumbered display of a window displaying said selected one of said plurality of computer application programs is controlled by the state of said display attribute.

4. The method according to Claim 2 further including the step of:
reverting the sequence in which said plurality of windows overlap to an original sequence in response to the conclusion of the output of data from said selected one of said plurality of computer application programs.

5. The method according to Claim 2 further including the step of:
maintaining said selectively altered sequence in which said plurality of windows overlap until such time as an output of data occurs from a second selected one of said plurality of computer application programs.

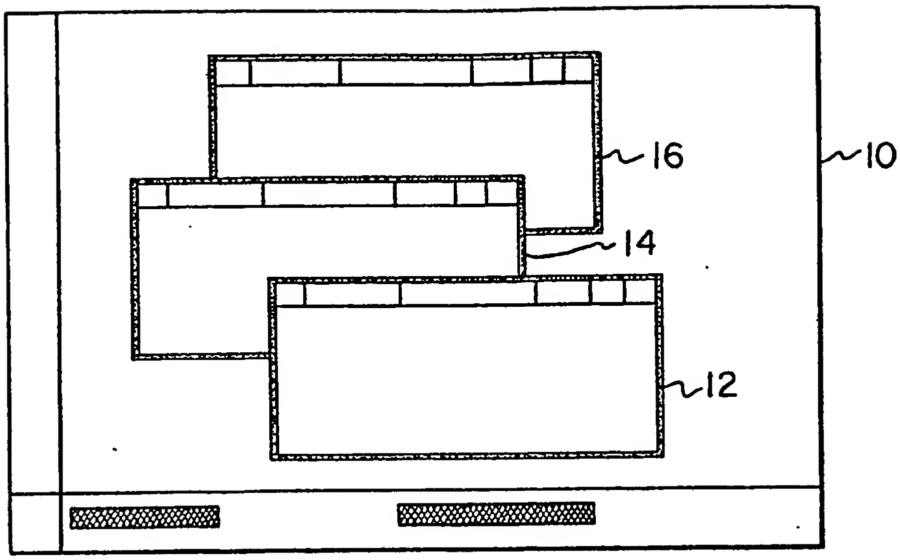

Fig. 1

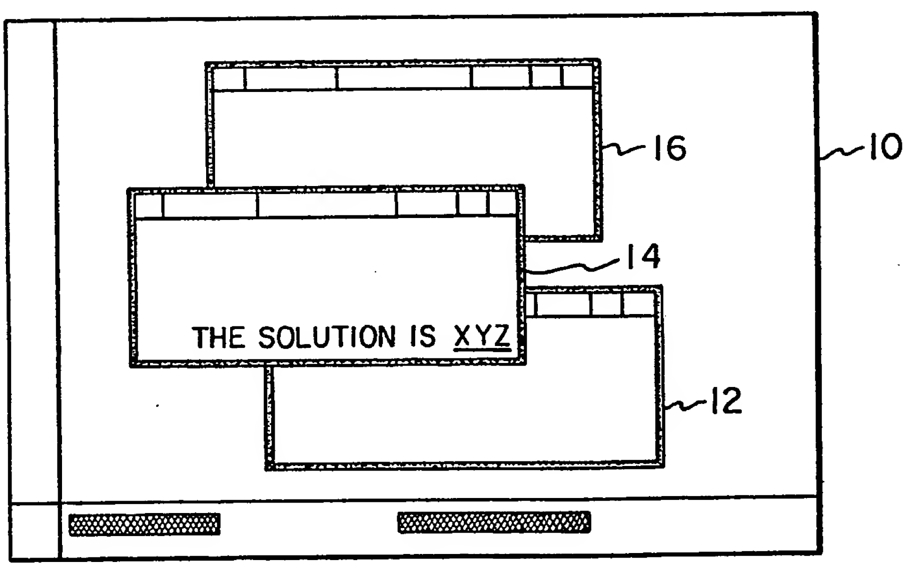

Fig. 2

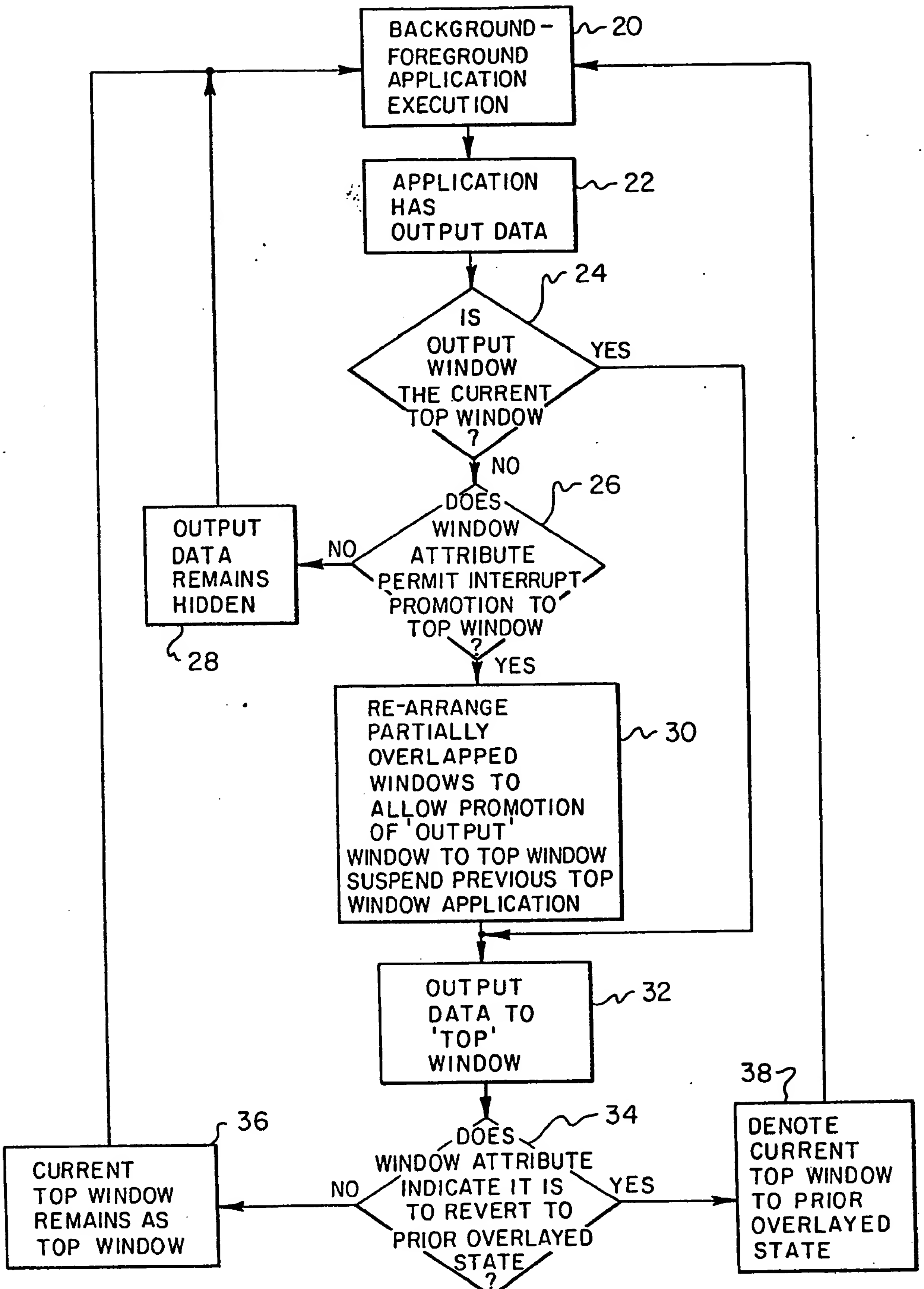
BACKGROUND-FOREGROUND APPLICATION EXECUTION
20
APPLICATION HAS OUTPUT DATA
22
IS OUTPUT WINDOW THE CURRENT TOP WINDOW ?
24
YES
NO
DOES WINDOW ATTRIBUTE PERMIT INTERRUPT PROMOTION TO TOP WINDOW ?
26
NO
OUTPUT DATA REMAINS HIDDEN
28
YES
RE-ARRANGE PARTIALLY OVERLAPPED WINDOWS TO ALLOW PROMOTION OF 'OUTPUT' WINDOW TO TOP WINDOW SUSPEND PREVIOUS TOP WINDOW APPLICATION
30
OUTPUT DATA TO 'TOP' WINDOW
32
38
DOES WINDOW ATTRIBUTE INDICATE IT IS TO REVERT TO PRIOR OVERLAYED STATE ?
34
NO
YES
CURRENT TOP WINDOW REMAINS AS TOP WINDOW
36
DENOTE CURRENT TOP WINDOW TO PRIOR OVERLAYED STATE

Fig. 3

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(71) Applicant: International Business Machines Corporation
Old Orchard Road
Armonk, N.Y. 10504(US)

(72) Inventor: Barker, Barbara A.
2800 Carmel Drive
Round Rock TX. 78681(US)
Inventor: Edel, Thomas R.
9410 Topridge Drive
Austin - TX. 78750(US)
Inventor: Stark, Jeffrey A.
2905 Valleyview Drive
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(74) Representative: Tubiana, Max
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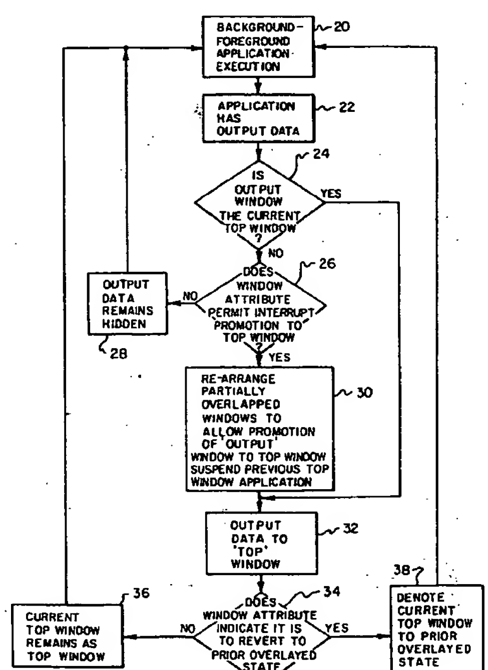

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number

EP 89 48 0081

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 247 827 (KABUSHIKI KAISHA TOSHIBA) * abstract; figures; tables 3-5 * * page 2, line 26 - line 49 * * page 3, line 21 - line 25 * * page 4, line 22 - page 5, line 55 * * page 6, line 54 - page 7, line 14 * – – –	1,2,5	G 06 F 3/033 G 09 G 1/00 G 06 F 9/46
A	COMPUTER vol. 19, no. 9, September 1986, NEW YORK, USA pages 57 - 67; B.A. MYERS: 'A Complete and Efficient Implementation of Covered Windows' * page 59, right column, line 51 - line 58 * – – – – –	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
G 06 F G 09 G

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	21 February 92	FONDERSON A.I.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

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G01S7/06
G01C23/00

THE C-17 MULTIFUNCTION DISPLAY A BUILDING BLOCK FOR AVIONIC SYSTEMS

Paul Weindorf

Honeywell Inc., Defense Avionics System Division
Albuquerque, New Mexico 87113

ABSTRACT

The C-17 Multifunction Display (MFD) has been developed by Honeywell Inc., Defense Avionics Systems Division, Albuquerque, New Mexico, under subcontract to Delco Systems Operations, Goleta, California, for use as the primary cockpit display system on the U. S. Air Force C-17A military air transport. The 6-inch by 6-inch color cathode ray tube (CRT) display features a self-contained 1750 processor and vector generator (VG) capable of processing MIL-STD-1553B aircraft data and raster video into any of 10 formats as selected by the pilot or copilot (see figure 1). The MFD can display stroke, raster, or hybrid formats in 16 colors. Raster images are driven by sensor inputs with an RS-170 or RS-343 interface. The CRT, manufactured by Tektronix, uses a taut mask delta gun design and provides the best available brightness and line-width performance. Due to its self-contained nature and multiformat capability, reconfigurability in the aircraft is enhanced by using four identical cockpit displays. Its small size, low weight, low power, standard interface, and adaptable software make the C-17 MFD an attractive choice for future avionic upgrades.

TECHNICAL SUMMARY

The superior performance of the C-17 MFD (refer to table 1) is due primarily to the use of the Tektronix delta gun taut mask CRT, together with its state-of-the-art triple-bandpass absorbing type contrast enhancement filter. A particular advantage is the high luminances the Tektronix CRT can support. Under high ambient lighting conditions, the C-17 MFD CRT, together with its filter, can support minimum visual performance for raster displays, while dome mask CRTs cannot. Note that the raster luminances and contrast ratios in table 1 represent a modified 675 raster where only 480 lines are active. This allows 30 percent of the video field time to be used for stroke overlays, but also reduces the raster brightness by approximately 30 percent compared to the normal 525 or 875 raster modes of operation. In addition, it is important to recognize that the stroke contrast ratios in table 1 are measured against a raster background at maximum brightness.

Table 1. MFD Performance Characteristics

Luminance:		Raster:	Stroke:
	Red	28 fL	115 fL
	Green	66 fL	293 fL
	Blue	10 fL	41 fL
Contrast ratio:		2K m/ft² ambient	8K lm/ft² ambient
	Stroke[1] (over maximum raster):		
	Red	2.0	1.55
	Green	3.9	1.4
	Blue	1.3	1.14
	Raster[2]		
	Red	1.7	1.1
	Green	2.6	1.4
	Blue	1.2	1.05
Line width (center):	Red/green	23 mils (max)	
	Blue	26 mils (max)	
	Red/green/blue	11 mils (min)	
TV scan resolution:	45 line pairs per inch at 100% brightness		
	60 line pairs/inch at 50% brightness		

1/ Raster is modified 675 where only 480 lines are active and traverse the entire screen.

2/ Stroke luminance is measured over an area of 16 lines written at 40 KIPS with line spacing equivalent to the raster spacing.

The triple-bandpass absorbing type contrast enhancement filter with an anti-reflection coating was chosen to match the three optical bandpass wavelengths with the emission spectra of the three primary CRT phosphors. Selecting the proper thickness allows both the luminance and contrast requirements of table 1 to be met. An absorbing-type filter was selected to meet the ±53 degree cross cockpit viewing angle for the C-17A aircraft.

Another benefit of the Tektronix CRT is its small uniform spot size due to its delta gun design in a 36 mm diameter neck. Compared to in-line gun designs with 29 mm necks, the delta gun CRT has the smallest and most uniform spot size of any shadow mask based CRT.

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OF THREE VOLUMES

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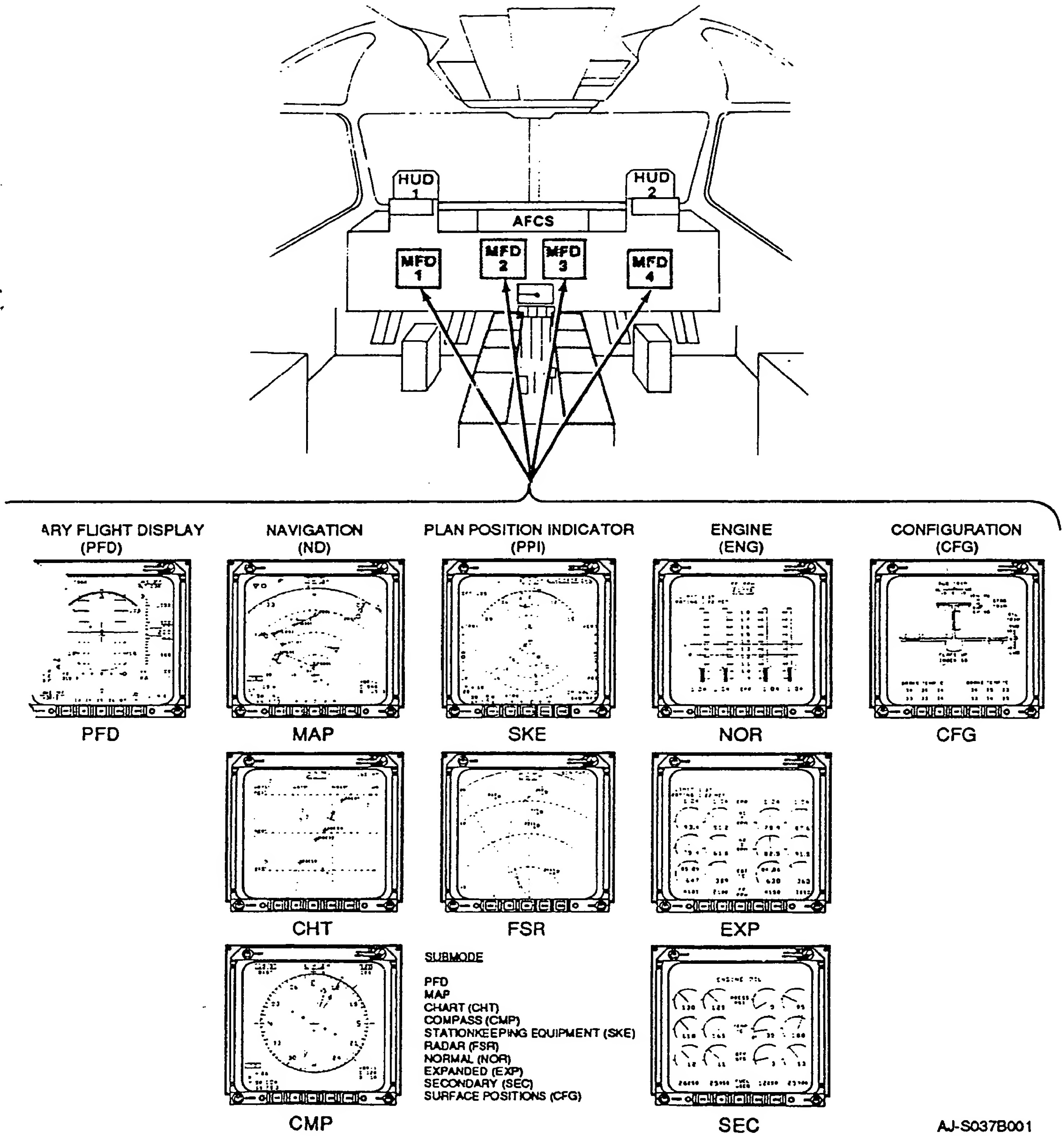

Figure 1. C-17A Cockpit with Display Formats

Using a 36 mm diameter neck together with the delta gun configuration allows a greater portion of the electron beam to pass through the distortion-free zone of the electrostatic lens. Much like optical lenses, the center region of the electrostatic lens gives the most aberration-free imaging of the electron beam spot. This delta structure yields the small uniform line widths shown in table 1.

Other MFD functional characteristics are shown in table 2, while physical characteristics are listed in table 3. Highlights include the multitude of video modes the MFD can support. The flexibility of supporting raster line rates commonly used in the military environment together with its hybrid stroke capability make the MFD highly adaptable for future applications. The range of stroke writing speeds from 8 thousand inches per second (KIPS) to 180 KIPS is also a significant technological achievement in light of the allowed power consumption.

Program Phase. The C-17 MFD has been qualified to military standards and is currently in production. The MFD has undergone producibility upgrades, and reliability improvements have been incorporated as a result of rigorous end-of-life durability testing. All factory tooling and test equipment are in place at Honeywell to support production.

Table 2. MFD Functional Characteristics

Video Modes:	Raster/Stroke/Hybrid at 1:1 aspect ratio
Video amplifier bandwidth:	30 Hz to 6 MHz (-3 dB)
Stroke writing speed:	40 KIPS symbology 180 KIPS high-speed stroke fill
Stroke resolution:	3,072 x 3,072 (0.002 inches)
Display jitter:	0.007 inch max
Integrated processor:	MIL-STD-1750A at 32 MHz 1.725 MIPS (DAIS mix)

Table 3. Physical Characteristics

Overall size:	8 in. H x 8 in. W x 15 in. L (14 in. behind panel)
Connector type:	2-Gang DPX MIL-C-81659
Weight:	37 lbs
MTBF:	7,335 hrs, MIL-HDBK-217E

MFD HARDWARE DESCRIPTION

The interface to the MFD, together with its functional subassembly descriptions and packaging concept, are detailed in the following paragraphs.

Interface Definition. The C-17 MFD has a simple, standard external interface (see figure 2). This standard interface makes the MFD the choice for a wide variety of applications. The external electrical interfaces, summarized in table 4, are described in detail in the paragraphs following the table.

Table 4. MFD Interface Characteristics

System:	MIL-STD-1553B multiplex data bus
Video:	RS-170 (525), RS-343 (875), modified 675, programmable for other line rates. Red, green, blue (RGB) with sync on green.
Power:	115 V ac, 400 Hz, single phase, 272 W max
Bezel:	5 Pushbuttons, expandable to 20. 0-5 V ac aircraft panel lighting power, 9.3 W max
RLS:	0 to 5 V (at 10,000 fL), ±15 V dc power
Cooling:	Forced air, 2.4 lb/minute at 32 °C; 1.4 in. pressure drop

1553 Interface. The 1553 interface consists of two triax channels (channels A and B), together with the remote terminal address and parity inputs. In the aircraft harness, each MFD is hard-wired for a unique terminal address, which allows identical MFDs to display different formats.

Video Interface. The raster video interface, labeled as WIU VIDEO in figure 2, consists of three triax red, green, and blue (RGB) inputs, with the synchronization signal on the green video input. In the C-17 aircraft, the red and blue video inputs are not used and only the green input is connected to the weather radar interface unit (WIU). The green input is used to display green radar ground map data or is flash-converted in the MFD to present color weather radar data.

Power Interface. Input power to the MFD is 115 V, 400 Hz, single-phase, and 0 to 5 V ac for the integrated bezel lighting. Although the C-17 specification allows 365 W of dissipation, the actual power dissipated for the C-17 formats ranges from 158 W at low brightness to 253 W at maximum brightness. The bezel lighting power ranges from 0 to 9 W as a function of the panel lighting voltage.

Bezel Pushbutton and Brightness Controls. The human interface controls on the front bezel control the format brightness, contrast, and mode of the display. Five tactile feedback pushbuttons are located at the bottom

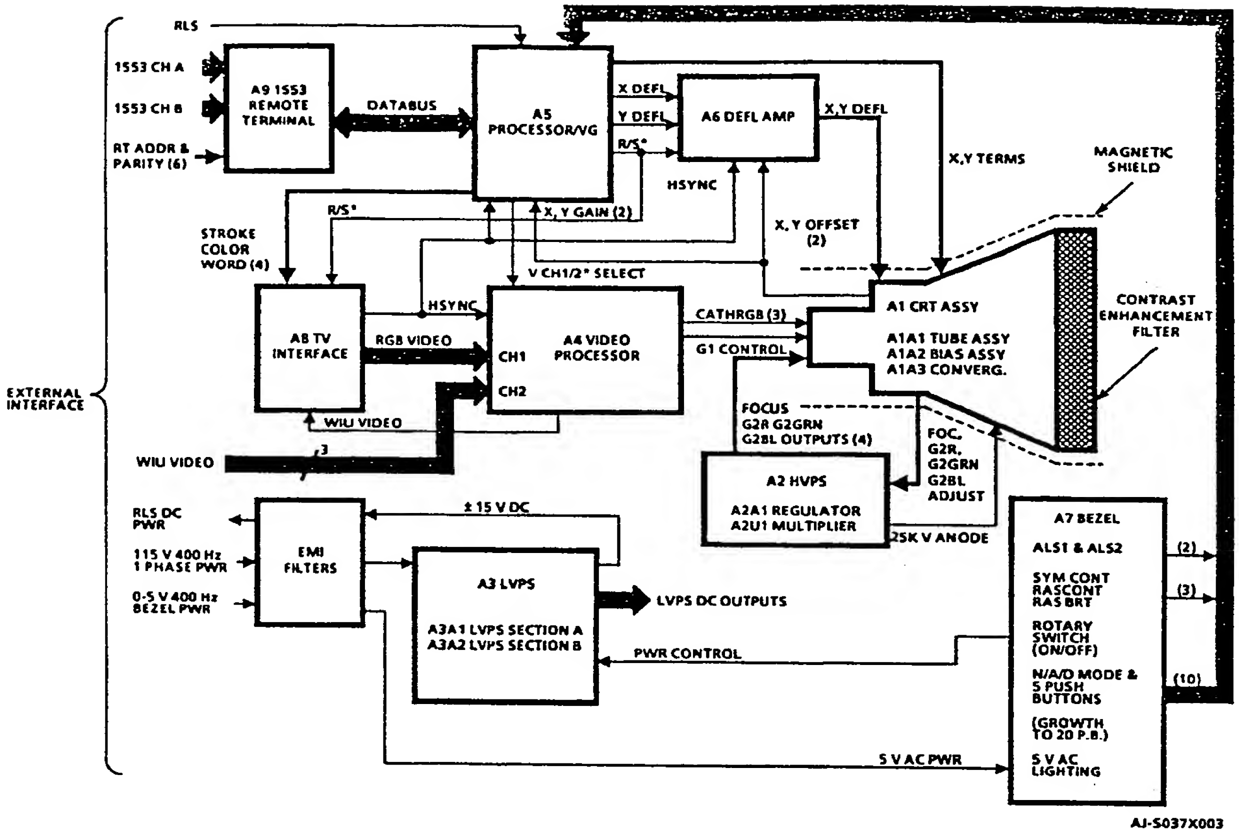

Figure 2. MFD Block Diagram

edge of the front bezel as shown in figure 3. Submodes of any format can be accessed by multiple pushes on a button (see figure 1). The bezel and internal interface circuitry are configured to allow for future bezel configurations with up to 20 pushbuttons. To adjust the display brightness and contrast, three rotary knobs are provided:

- Stroke Symbol Contrast Control (SYM) - varies the brightness of the stroke symbology.
- Raster Contrast Control (R-CTRS) - varies the gain or contrast of the raster video and brightness of the high speed fill symbology.
- Raster Brightness Control (R-BRT) - varies the overall brightness of the raster video display.

A fourth discrete rotary selector switch allows the MFD to be turned off or to operate in one of three modes.

- Day - the manual brightness and contrast controls have their full range of operation.
- Night - the manual brightness and contrast controls are scaled down to 5 percent of the maximum day range.
- Auto - the automatic contrast control function utilizes the forward looking remote light sensor (RLS) and the ambient light sensors (ALS) on the bezel to automatically adjust the display contrast as a function of changing lighting conditions. Use of the automatic contrast control mode on the MFD minimizes the need for frequent manual adjustments, under high workload operations, of display luminance during dynamic changes in cockpit illumination and forward field of view intensity. Additionally, use of the automatic mode does not drive the display to a higher luminance level than required and consequently increases the life of the CRT.

Physical Interface. The MFD is designed to simplify mechanical and electrical connections to the aircraft and is installed easily by one person. An important component of the mounting system is the MFD's carrying handle, which also engages and secures the

MFD to the aircraft. During engagement, the rear surface of the display contacts the blind-mated electrical connector (refer to table 3) and spring-loaded valves that carry the cooling air for the MFD to and from the closed-loop avionics cooling air system. At the rear of the MFD are cooling air orifices, 2-inch holes, each of which can be used as either an inlet or outlet for the cooling air.

MFD Subassembly Functional Descriptions. To enhance testability and fault isolation, the nine subassemblies inside the MFD electrical chassis are functionally divided as shown in figure 2. A brief description of each subassembly's functional characteristics follows.

- A1 CRT Assembly - The A1 CRT assembly is comprised of the Tektronix CRT and its shielding, a contrast enhancement filter, deflection and convergence yokes, digital convergence electronics, and miscellaneous circuitry to remotely control gains and bias voltages sent to the CRT assembly.

- A2 High Voltage Power Supply (HVPS) - The A2 HVPS receives its voltages from the A3 Low Voltage Power Supply (LVPS) and develops the anode, focus, and three separate RGB G2 voltages for the A1 CRT assembly.

- A3 Low Voltage Power Supply (LVPS) - The A3 LVPS receives and converts 115 V ac, 400 Hz, single-phase aircraft power to 12 secondary voltages for the electronic assemblies in the MFD.

- A4 Video Amplifier - The A4 Video Amplifier amplifies and offsets the raster WIU VIDEO or the raster/stroke RGB video from the A8 TV Interface Assembly as a function of the contrast and brightness control settings.

- A5 Processor/VG - The Processor/VG is a 7.3-inch by 9.3-inch two-sided leadless chip carrier (LCC) assembly that contains a 1750A processor and a VG for format generation.

- A6 Deflection Amplifier - The A6 Deflection Amplifier converts the X and Y deflection signals from the A5 Processor/VG into the deflection currents necessary to drive the electromagnetic yokes on the A1 CRT assembly.

- A7 Bezel Assembly - The integrally illuminated A7 Bezel assembly is mounted on the front of the MFD and is comprised of five pushbutton switches, a four-position rotary selector switch, three potentiometers, and two ambient light sensors.

- A8 TV Interface Assembly - The A8 TV Interface assembly flash converts color weather radar video, converts digital RGB stroke data to analog video, strips the raster video synchronization signals, and generates a raster color bar test pattern.

- A9 1553 Remote Terminal (RT) - The A9 1553 RT accepts 1553B data bus information via a dual data bus (channels A and B) and provides this data to the A5 Processor/VG through dual-port random access memory (RAM).

MFD Packaging. The MFD's packaging is designed for easy access and maintenance. An exploded view of the MFD packaging concept is shown in figure 3. This design allows for singular electrical assembly replacement without removing other assemblies, with one exception. The A7 Bezel must be removed to replace the A1 CRT assembly. Impingement cooling allows the MFD to meet a severe 1.4 inch of water pressure drop at a 2.4 ppm flow rate requirement. Impingement cooling also reduces the MFD weight to under 37 pounds by eliminating cold wall conduits required by isolated cooling air systems. The MFD, with an integrated display processor, reduces system weight by approximately 35 pounds and increases reliability by over 1,000 hours when compared to separate display processor systems.

Design Innovations. Several innovations during the C-17 MFD development process proved to be instrumental in overcoming major hurdles in the areas of power management, reliability, and maintainability. Most notable of these are the power saving deflection amplifier, synchronizing HVPS, and digital convergence inventions.

Power Saving Deflection Amplifier. The power saving deflection amplifier provides a power savings of 78 to 100 W over a standard class B amplifier. Historically, hybrid raster/stroke deflection amplifiers have required a great deal of power. This is further aggravated by the color CRTs' large neck size. This innovation allows energy stored in the inductive deflection yoke to be recovered automatically and pumped back into the power supplies. By reducing the power requirements of the deflection amplifier, power in the LVPS is also saved. This results in a 25 percent decrease in the specification's power requirement, and a 50 percent increase in reliability.

Synchronizing HVPS. The synchronizing HVPS efficiently provides a wide dynamic range of anode currents required by high brightness color CRTs. In general, constant frequency standard pulsewidth modulating techniques used in switching low voltage supplies cannot be used due to the large interwinding capacitance of high voltage transformers. The

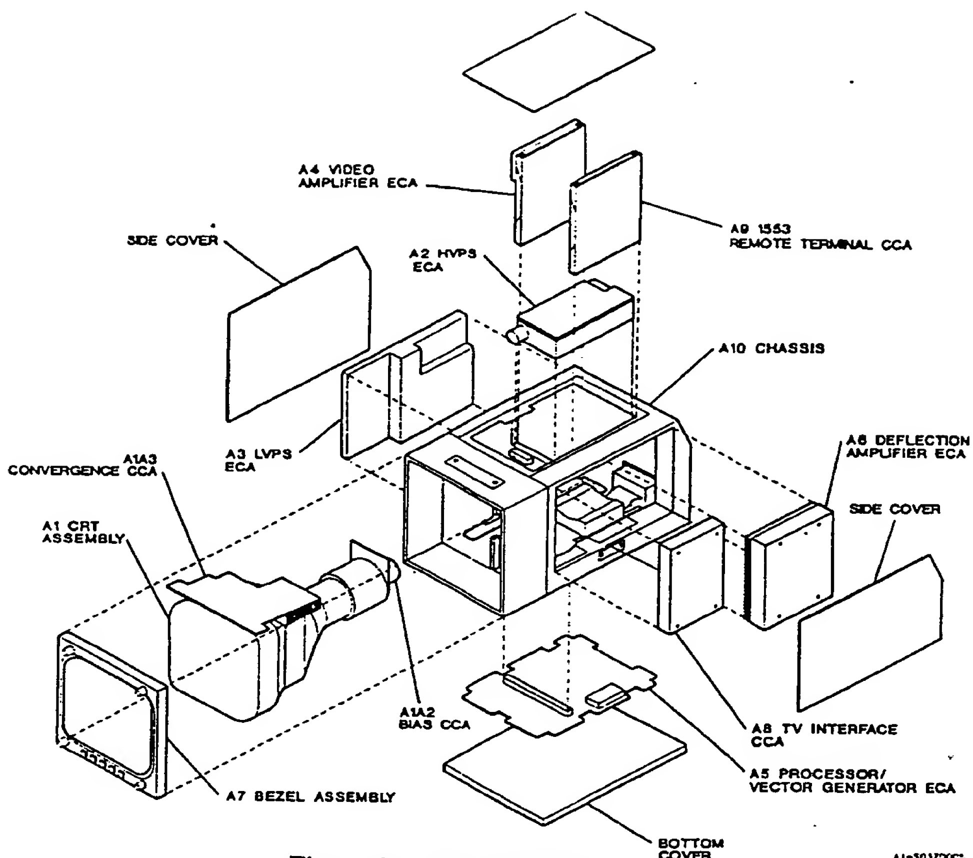

Figure 3. MFD Packaging

synchronizing HVPS dramatically increases the dynamic range by using a variable frequency pulsewidth modulating technique. The key innovation is the flyback pulse negative slope detection function, which is used to synchronize a pulsewidth modulator to a time varying flyback pulse. This technique provides for anode currents of 0 to 5 mA at increased efficiency, which represents a dynamic range improvement of 5 to 1 over past designs.

Digital Convergence. The digital convergence approach on the MFD meets a 10 mil convergence requirement without the use of potentiometers. Prior to this innovation, to meet a 10 mil convergence on a delta gun shadow mask CRT over the entire screen many potentiometers or select resistors were used together with many analog multipliers that had notorious offset drifts over temperature. Maintainability problems in the field occur when analog convergence systems are used. In the digital convergence system used in the MFD, polynomial coefficients are selected at nine screen locations on a support computer system (see figure 4). The software algorithms calculate the data to be loaded into the memory mapped ultraviolet programmable read-only memory (UVPROM) for the nine locations plus all of the intermediate locations. The memory structure in the programmable read-only memory (PROM) and the waveform reconstruction filters are selected to eliminate undersampling of the correction waveforms. Because the digital screen address is available from the A5 Processor/VG, the use of digital convergence in the C-17 MFD is accomplished easily without circuitry to convert an analog deflection screen position into a digital screen address. Advantages of digital convergence include meeting 10 mil convergence over temperature with simplified circuitry and improving the reliability and maintainability due to the elimination of potentiometer adjustments.

MFD SOFTWARE

The C-17 MFD computer program contains about 23,500 source lines of code that perform real-time display control and symbol processing. Approximately 99 percent of this code is in JOVIAL high order language (HOL), which provides a well documented and maintainable program. The remaining 1 percent of this code is written in assembly language, which improves throughput performance of repetitive utilities. The program is stored in 76K words of ultraviolet erasable programmable read-only memory (UVEPROM) that can be programmed during fabrication or in the field. About 20K words of RAM are used for scratchpad and display symbol processing.

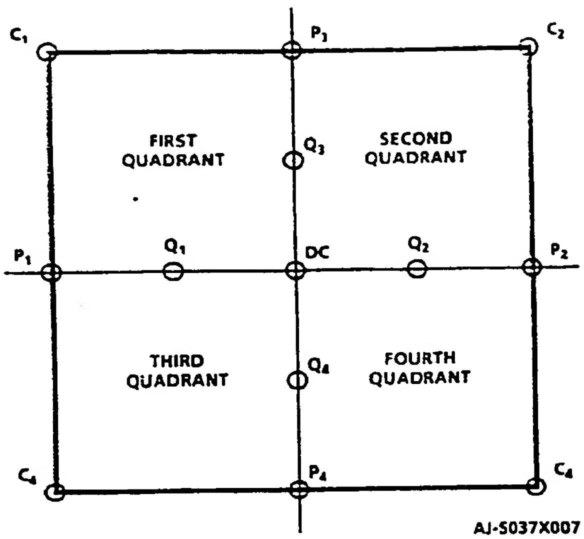

Figure 4. Convergence Correction

The computer program interfaces with the MFD hardware to:

- Select format
- Handle 1553 mux bus data
- Perform built-in-test (BIT)
- Perform brightness and contrast control
- Update display

The Select Format function enables the pilot to request any one of 10 different display formats via the front bezel pushbuttons. This bezel pushbutton request for a new format is also transmitted over the 1553 bus to the mission computer, which in turn begins transmitting avionics data to the MFD. The avionics data is then processed into the format symbology and integrated with the skeleton format to provide the complete display.

The 1553 data is transmitted to the MFD at variable rates: 25 Hz, 12.5 Hz, and 6.25 Hz. All of the data is processed at the fastest message rate for the specific format, typically 25 Hz (40 ms).

The MFD software also performs comprehensive diagnostic BIT functions, capitalizing on the integrated processor design. The BIT software provides fault detection, isolation, and storage, thereby enhancing field maintainability. BIT is performed at power-up, periodically (at least once every 160 ms), and by request (when on the ground). Individual BIT failures are identified and recorded into nonvolatile RAM (NVRAM) to facilitate diagnosis and repair.

The brightness and contrast control of the MFD is achieved by combining software and hardware. In the day and night modes, the software applies a fixed gain to the bezel brightness and contrast control knobs. The auto mode software algorithms use light sensor data to control the brightness of the display formats.

The display update process is the primary function of the computer program. This program processes basic avionics data into VG language at a rate equal to the highest 1553 receive message rate (25 Hz, worst case). Some of the symbology requires real-time construction using the VG instructions. Alphanumeric and punctuation characters in 5-point size and many other display symbols are generated from VG instructions that are stored in PROM. This allows for easy translation and rotation. The software also sets up hardware occlusion zones that prioritize symbology and create display windows for moving scales and rolling digits. Since the navigation symbology is not limited to the MFD viewing area, and the rotation value is variable, special processing is required to limit lines and arcs accurately. This requires implementation of the Cohen-Sutherland line clipping algorithm and a custom developed arc clipping algorithm.

SUMMARY

The C-17 MFD is expected to support the needs of modern airlift fleet well into the next century. With its self-contained processor and VG, the MFD software can be modified easily to create new display formats for a variety of applications. Its simple standard interface, together with its superior performance, make the MFD an ideal building block for reliable and easily maintainable avionic upgrades.

Acknowledgement of Sponsorship
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